



**Title:** Project Execution Planning for Building Information Modeling

**Proposal Date:** January 8, 2008

**Grantee Organization:** The Pennsylvania State University

**Principle Investigator:** John I. Messner, Ph.D.  
 Associate Professor of Architectural Engineering  
 Director, Computer Integrated Construction Research Program  
 104 Engineering Unit A  
 University Park, PA 16802  
 (814) 865-4578 (phone)  
 (814) 863-4789 (fax)  
[jmessner@engr.psu.edu](mailto:jmessner@engr.psu.edu)

## Summary:

The goal of this research is to develop and broadly disseminate a method to create a Building Information Modeling (BIM) Execution Plan in the early stages of a building project. Many owners and project teams are currently struggling with defining the appropriate level of modeling to perform on a construction project based on the current state of practice and their future information needs. This guide, developed primarily for facility owners and early project participants, will focus on the decisions required to define the scope of BIM implementation on the project, identify process impacts of using BIM, define the team characteristics needed to achieve the modeling, and quantify the value proposition for the appropriate level of modeling at the various stages in the project lifecycle.

The guide will be developed based on sound metrics and data from expert interviews, focus group meetings, case studies and existing reference sources. The initiative will be performed as a buildingSMART Alliance project which will facilitate the broad dissemination of the project results. The industry champion is Dana 'Deke' Smith, the director of the buildingSMART Alliance. This proposal will be co-funded by The Partnership for Achieving Construction Excellence (\$20,000) along with the Pennsylvania State University Office of Physical Plant, who will support a graduate student to work on this project throughout the life of the project (value of \$61,137). The results will be disseminated through the buildingSMART website along with presentations at major industry conferences, e.g., AIA, AGC, buildingSMART, DBIA, CMAA, and others.

# Project Execution Planning for Building Information Modeling

## INTRODUCTION AND JUSTIFICATION

The vision of Building Information Modeling (BIM) is to allow project teams to digitally model a building and its performance prior to construction, and collect, store and use digital information efficiently and accurately throughout the project lifecycle. This vision is the focus of many recent construction projects that are implementing a BIM process, yet to date, most projects are using isolated BIM techniques for targeted tasks. The overarching goal for the development of a large integrated digital model which is created at the beginning of the project, and then developed, and used throughout the project lifecycle remains very limited.

A current challenge and opportunity faced by the early project planning team is to identify the most appropriate uses for Building Information Modeling on a project given the project characteristics, participants' goals and capabilities, and the desired risk allocations. This proposed research will focus on helping project teams to evaluate and implement appropriate BIM applications and processes by providing a decision matrix to assist in the definition of BIM applications, and guidelines for implementing BIM at various stages of the project.

The most significant current initiative related to BIM in the U.S. is the development of the National Building Information Modeling Standards (NBIMS) by the National Institute for Building Sciences. NBIMS is focused on the creation of data exchanges between the various participants in a building project. They are developing teams to identify specific needs within the industry for focused data exchanges, e.g., the COBIE project for data exchange to the operations and maintenance systems. The NBIMS project is part of the buildingSMART Alliance of the International Alliance for Interoperability – North America which has recently increased their focus on the process changes that must occur within the industry to accelerate the adoption of BIM. This research will be performed as a project within the buildingSMART Alliance and will closely tie into the NBIMS initiative to leverage from the current committee work and to broadly disseminate the final results.

## GOALS AND OBJECTIVES

The goal of this research is to develop and broadly disseminate a method to create a BIM Execution Plan in the early stages of a building project. The execution plan will define the scope of BIM implementation on a project, the team characteristics needed to achieve the modeling, the process impacts of using BIM, contract recommendations for BIM implementation, and the value proposition for the appropriate level of modeling at the various stages in the project lifecycle. The primary audience for this method will be facility owners along with other project participants who provide advice to the owners during the early planning stages of a project include architects and construction managers.

Specific objectives that will be achieved include:

- 1) **Identification of BIM methods and implementation strategies** organized by project phase (planning, design, construction, and operations) and the definition of potential benefits, costs, and strategies for adopting these methods;
- 2) **Develop the implementation guidelines** and best practices for BIM implementation at various stages in the project; and
- 3) **Disseminate the results** through A) a BIM Execution Planning guide, B) an interactive execution planning computer application that will lead a project team through the collaborative planning process, C) presentations at buildingSMART and other national

conferences, e.g., AIA, AGC BIMForum, DBIA, etc., and D) articles in industry and academic publications.

This research will be conducted using rigorous research methodologies to identify and quantify the impact of BIM implementation during various project phases. We will use interviews, case studies, and quantitative data analysis to develop an initial execution planning framework which will provide a team with the data and knowledge to decide the most appropriate modeling strategies to implement on their project. An initial draft of the execution planning guide will be published to a website after the first year of the project, and distributed to NBIMS and buildingSMART Alliance members for comment. Then, we will pilot test the implementation guide by having several different owners use the execution planning guide on their projects to develop a BIM execution plan. Finally, we will create a simple computer application that will allow a planning team to interactively develop the BIM execution plan while stepping through the various items that are needed, analogous to a wizard type feature in an income tax application. The output of the planning process will be a customized BIM execution plan that clearly defines the strategies to be used on the project and how they will be implemented, e.g., team player responsibilities, contracting strategies, model structure / level of detail, and model submission requirements.

The final research project outcomes will include:

- 1) **BIM Execution Planning Guide:** This document, posted electronically, will include the decision matrix and guidelines for BIM implementation at various project phases. This document will be posted and distributed by the buildingSMART organization.
- 2) **BIM Execution Planning Application:** This will be an easy to use application for guiding a team through the decisions required for creating the project execution plan for BIM. It will be based on the Execution Planning Guide for BIM.

### **BENEFIT TO THE INDUSTRY**

*“Building Information Modeling (BIM) is currently in its ‘wild West’ phase and this research promises to help develop a structure for planning a model for the most cost effective use of modeled information. Currently, owners are becoming aware that they need BIM but there are no norms yet established to help them understand the value chain of investment verses return. I anticipate the outcome of this effort to be a critical step along that path that will help not only the decision maker / owner, but the overall BIM effort in general.”*

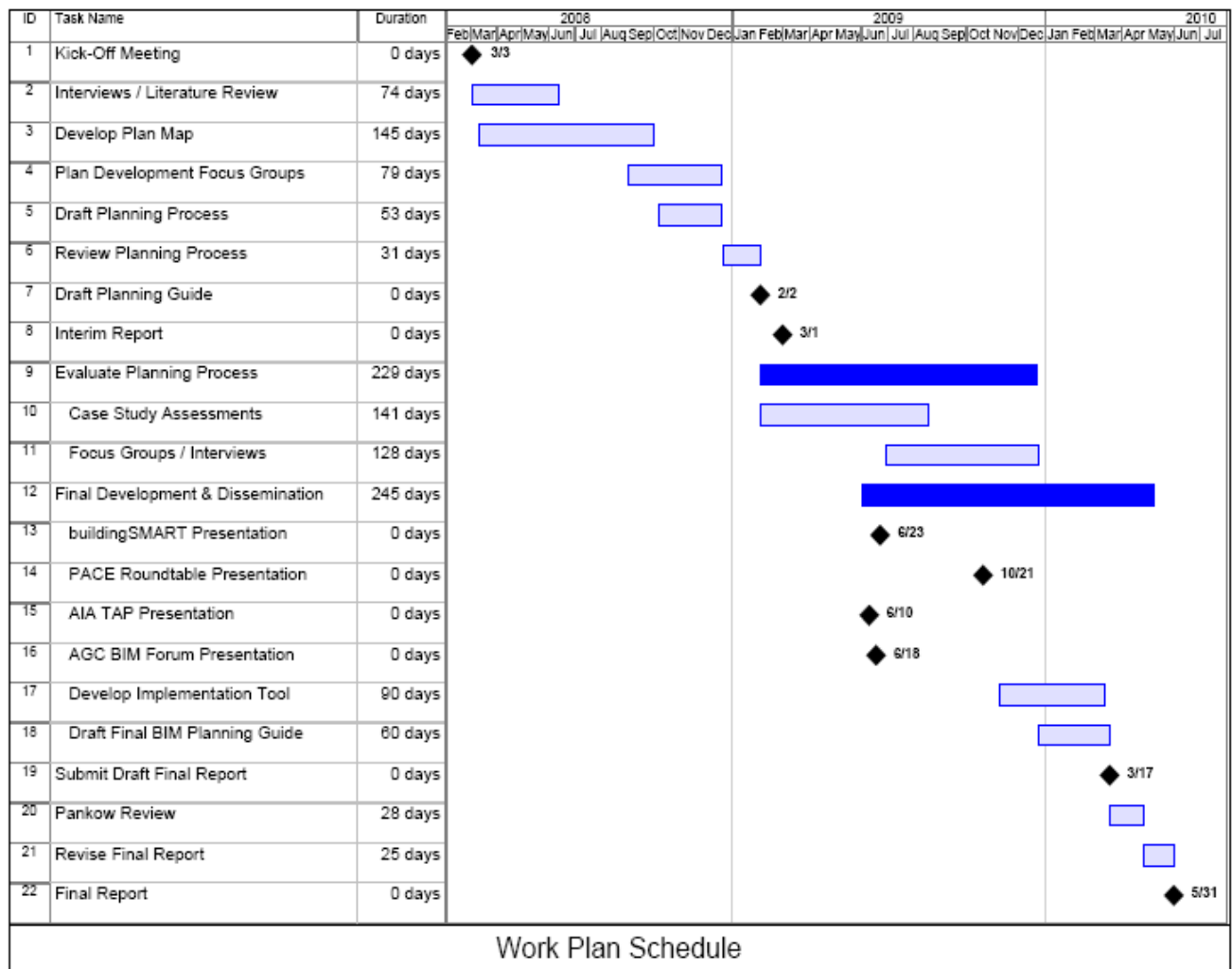
- Dana ‘Deke’ Smith, Executive Director, buildingSMART Alliance

Many owners and project teams are struggling with defining the appropriate level of modeling to perform on a project based on the current state of practice and future information needs. The BIM execution planning guide will help owners, program managers, and early project participants to craft a comprehensive BIM plan, based on sound metrics and data. The guide will also be valuable to designers, contractors, and other project participants who are aiming to provide quantitative metrics developed through a rigorous research process to the project team regarding the potential benefits of using various components of BIM on a project along with best practices for implementation. Additional side benefits include the education of both undergraduate and graduate students in the current application of BIM in the industry. These students may someday become champions in their future employers.

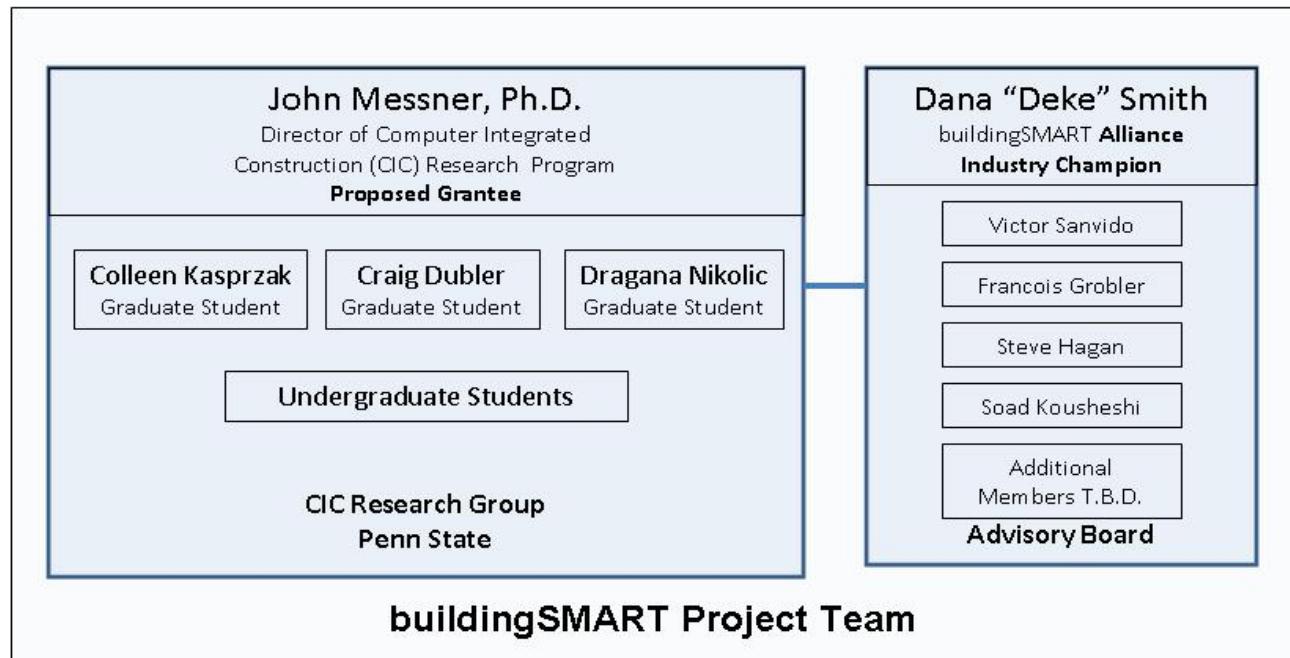
## **WORK PLAN**

- 1) **Perform interviews and a detailed literature review** to identify the BIM methods that can be implemented at the various project phases, along with the opportunities and challenges encountered with the adoption of BIM in various phases of the execution.
- 2) **Develop a Draft Planning Process** which will identify the important decisions that need to be made by an owner / project team related to BIM implementation, along with potential strategies. We do not envision the process providing the answer on how to implement BIM for each project type, but instead the goal is to have the process identify the proper questions that the team should be addressing, along with potential suggestions for appropriate uses of BIM developed from the literature, at least 3 focus group meetings with industry members, expert interviews, and an analysis of industry case studies. The planning process will help an owner and project team members to define the appropriate level of detail for a model (e.g., Tier 1 Information Delivery Manual (IDM) exchange requirements to implement on a project) along with appropriate implementation methods regarding the BIM for various disciplines. This will be tightly integrated with the ongoing development of the IDMs as defined within the National Building Information Modeling Standard. A specific section focused on quantitative metrics for BIM application to facilitate future data collection and quantification of BIM benefits will be included. In the fall of 2008, a special topics course will be offered at Penn State to engage graduate students in the assessment and further development of each of the primary sections within the planning guide. This will allow for greater student participation, as well as allow for a broader assessment of the document. We anticipate that approximately 15 to 20 students will participate in the course.
- 3) **Complete Interim Research Product – A Draft BIM Planning Guide** will be published approximately halfway through the project. A web-based version of this information will be utilized for easy access and management. Please note that this information will be helpful for BIM customers, however use of this information will require caution since the assessment of the product will not be complete. For this reason, Penn State will limit access of this information to CPF, project experts, buildingSMART Alliance members, and other selected industry members for evaluation and assessment.
- 4) **Test, Assess and Revise the Planning Process** through an analysis of at least 15 detailed case studies, and through the adoption and testing of the methodology on several design and construction projects. We would seek to have at least five owners, designers, and contractors adopt the use of the initial draft process and provide feedback for improving the planning method and documentation of the method. The Penn State Office of Physical Plant (a co-funding organization for this project) has already committed to use the future guide on their projects for assessment. Additional owners, e.g., GSA, have also expressed an interest in participating in the implementation and case study portion of this project. Human factors that affect the success of BIM implementation on a project will also be reviewed throughout the case study analysis. During this phase, the research team will be working with Sam Hunter, an industrial psychologist at Penn State, to compose and review interview questions regarding project team factors which either impede or enable the successful implementation of BIM. These factors will be developed into human factor guidelines to advise organizations about potential factors to consider when adopting BIM technologies. Additional human factors related to training, communication, and owner buy-in will also be considered as part of the research guidelines.

- 5) **Develop Final BIM Planning Guide** that clearly defines the BIM Execution Planning Process in an easy to use document. The goal of the guide will be to lead a project team through the decisions that they need to make at the early stages of a project to set up the BIM strategy. We envision that these decisions would include factors such as team selection criteria, model scope definition, contracting strategies, and process recommendations.
- 6) **Develop a BIM Planning Application** that will more easily allow a project team to develop the BIM Execution Plan in a planning meeting. This computer application will step the project team through the planning process in a more interactive format, and point the team to additional references and information that are appropriate during the planning process. We envision that this application will be a database of the various topics with potential solutions that the project team would use, as a group, to answer the important project decisions. After entering their decisions, they can print and distribute the BIM Execution Plan for the project.
- 7) **Disseminate BIM Planning Guide and Application** through the buildingSMART Alliance as well as presentations to various industry groups (i.e. PACE, AIA TAP, DBIA, AGC BIM, etc). Please reference the Dissemination Plan which follows for more information.



## **INDUSTRY COLLABORATION**



**Industry Champion:** Dana "Deke" Smith, Executive Director, buildingSMART Alliance

**Proposed Grantee and experts:** Dr. John Messner is the Director of the Computer Integrated Construction Research Program at Penn State and will be the principle investigator. Three graduate students at Penn State will be dedicated to the project along with support from undergraduate students. An advisory board will also play a critical role in guiding this research. Members who have already agreed to actively participate include:

- Deke Smith, Executive Director, buildingSMART Alliance (Industry Champion)
- Victor Sanvido, Ph.D., Senior Vice President, Southland Industries
- Francois Grobler, Ph.D., US Army CERL and IAI - North America
- Steve Hagan, Project Knowledge Center, U.S. General Services Administration
- Soad Kousheshi, President, AEC Strategy
- Ed Gannon, Design Services Manager, Penn State Office of Physical Plant (OPP)

Additional participants will be identified from buildingSMART, the NBIMS Project Committee, the Partnership for Achieving Construction Excellence (PACE) and the CIC Research Program member companies. The advisory board will meet either in person or via conference call at least every quarter, and more frequently as needed. The board will guide the research, aid in the collection of data, review all products of the research, and play an important role in presenting and distributing the results.

## **DEGREE OF COMPLETION**

At the completion of this project, the BIM planning guide and planning application will be completed implementation resources for the industry. Both items will be ready for implementation by building planning, design and construction teams. To keep up with the dynamic changes occurring with BIM adoption during the period of research, the project team will proactively incorporate external factors as they change through the help of the industry experts and project personnel. A collaborative web-based version of this application will be developed by the research team and housed on a project website which can be easily modified when additional information is available. In addition, an interim research product, designed to provide timely value for the users of the BIM planning guide and planning application, will

be developed approximately halfway through the period of research. Details regarding this interim product are provided in the Work Plan section of this proposal.

### **DISSEMINATION PLAN**

This project will be administered as a buildingSMART Alliance project which will allow for broad dissemination to industry including owners, designers, contractors, and facility managers.

The information developed will also be disseminated through presentations at major industry group functions (buildingSMART, AIA Technology in Architectural Practice, AGC BIM Forum, DBIA, PACE, and others) as well as articles published in industry and academic publications and journals.

We will present the current status of the project to industry members within the PACE (Partnership for Achieving Construction Excellence) organization, as well as to CPF, for both dissemination as well as identifying focus group and interview participants. PACE is a working partnership between Penn State students, faculty, and building industry practitioners such as owner representatives, design professionals, engineers, and construction managers.

We will also disseminate the results of this research directly to the owners, architects, contractor and facility managers that collaborate with us on case study implementation through implementation examples in their organization. Of particular note is the Penn State Office of Physical Plant (OPP), the owner's representative for all Penn State facility projects. Penn State owns and operates well over 1,000 buildings at University Park, The Dickenson School of Law, Hershey Medical Center and the Commonwealth Campuses. They are constantly adding to the inventory by building new facilities, and the current Capital Construction and Renewal Plan calls for approximately \$1.3 billion in construction.

Finally, student participation will be an additional form of dissemination. The graduate and undergraduate students who work on this project and participate in the development of the planning application will be gaining valuable experience on the implementation of BIM on construction projects. They will take this knowledge with them into the industry and many will become future champions of BIM initiatives in the industry.

### **DIFFUSION ASSESSMENT PLAN**

Upon completion and publication of the BIM Planning Guide and Application, a diffusion assessment plan will be implemented. This plan will determine the extent to which intended users in the building design and construction industry have adopted, used, and benefited from the BIM Planning Guide and Application. The following is an outline detailing the diffusion assessment plan:

- **Website** - The assessment website will be developed prior to the completion of the research. It will be used to host a questionnaire for collecting data from projects that implement the BIM Application. The data will be collected and analyzed to evaluate the dissemination level and potential future improvements.
- **Case Study** (Penn State Office of Physical Plant) – It is recommended that the advantages and constraints of the BIM Planning Guide be monitored within Penn State's OPP for at least 2 years following the research completion. The information gathered from this organizational adoption case study will be very useful for other larger corporations seeking to take full advantage of BIM through continuous project improvement.
- **Focus Groups** – It is recommended that a series of focus group meetings be conducted during the buildingSMART conference in early December 2010 and 2011 (Approximately 6 and 18 months beyond project completion). The focus groups could be separated by organizational type (e.g., owner, designer, builder, facility manager). These focus groups will specifically investigate the value added by the guide through the entire building process, and seek specific areas for improvement.

Please note that the above is a tentative plan for diffusion assessment. A final plan will be developed during a conference between PSU and CPF prior to project completion.

## **PERSONNEL**

### **John I. Messner, Ph.D.**

Dr. Messner serves as the Director of the Computer Integrated Construction (CIC) Research Program at Penn State. His research focuses on the use of Building Information Modeling and advanced visualization technologies to improve project design and construction along with the educational adoption of BIM. He currently has several ongoing research projects focused on BIM and virtual prototyping. One of these projects is a three-year collaborative Engineering Education grant from the National Science Foundation (NSF) which supported the construction of a new visualization lab (the ICon Lab) to implement interactive educational case studies with full-scale virtual prototypes. He has also received a five-year NSF CAREER Award for investigating the value of virtual prototyping for fostering innovation and knowledge management in the design and construction planning process in both industry and academia.

In addition to his construction visualization research and education initiatives, Dr. Messner is also continuing to expand research efforts in the areas of construction globalization and strategic management in construction procurement methods. He led a research project with the Construction Industry Institute (CII) to investigate the appropriate use of the global engineering workforce in the Engineering, Procurement and Construction (EPC) Industry. He also performed a study for the National Academy of Engineers focused on the impact of Offshore Outsourcing on the Construction Industry along with a procurement method study for the Design-Build Institute of America (DBIA). He has also worked in industry as a field engineer, project engineer, project manager, and project superintendent.

### **Dana “Deke” Smith**

Deke is the Executive Director of the buildingSMART™ Alliance an emerging program of the National Institute of Building Sciences (NIBS) to improve construction productivity through interoperability. He was the founder and former chair of the NIBS Facility Information Council, home of the US National Computer Aided Design (CAD) Standard and the evolving National Building Information Modeling (BIM) Standard. Deke is a senior analyst with the International Centre for Facilities and also a senior analyst with CYON Research, and has his own information consulting firm. He participated in the beginnings of the NIBS Construction Criteria Base and was on both American Institute of Architects (AIA) CAD Layering Guideline efforts as well as the National Institute of Science and Technology (NIST)/ Construction Specifications Institute (CSI) Uniformat II. He was the U.S. representative for facility related CAD to the International Standards Organization (ISO) in the 1990's. He was a winner of the 1996 Federal 100 award, 1997 NIBS Member Award and the 2006 CAD Society Leadership award. He is a registered architect in Virginia and has worked as a surveyor, assistant field engineer, facility designer, cost engineer, value engineer, life-cycle cost analyst, deputy CIO, and was the chief information technology (IT) architect for the DoD Business Transformation Agency's modernization effort for installations and environmental issues before his retirement after 30 years with the DoD.

### **Craig Dubler**

Craig is a graduate student with a focus on implementing Building Information Modeling in the construction industry. He received both a Bachelors and Masters of Architectural Engineering at The Pennsylvania State University in 2004. Upon completion of his degrees, he worked for two general contractors in the Washington D.C. area: Hensel Phelps Construction Co. and James G. Davis Construction Corp. (DAVIS). During his time at Hensel Phelps, he gained valuable knowledge in the field operations as a Field Engineer. Later, he transferred to DAVIS where he worked as an Assistant



Project Manager on two high end office buildings. Craig recently returned to Penn State to pursue his PhD degree.

### **Dragana Nikolic**

Dragana is a PhD student in the Architectural Engineering Department at The Pennsylvania State University since September 2006. She has a Bachelor in Architecture from University of Belgrade (2003) and received her Master's in Architecture from Penn State in 2006. Her research interests are in the fields of Building Information Modeling, Virtual Facility Prototyping and Immersive Virtual Reality. She also has experience with implementing BIM through a research initiative with The Foreman Group.

### **Colleen Kasprzak**

Colleen is an M.S. graduate student focused on research related to the implementation of Building Information Modeling for facility asset management. She received her B.S. in Architecture with a minor in Spanish in May 2006 from Penn State. She currently works full time as an Architectural Designer II for Penn State Design Services at the Office of Physical Plant. As a designer, she focuses and offers all support during project design phase development, collaborates with other disciplines on project solutions, as well as prepares all design and construction documentation in coordination with construction administration. She will transition to working at least 55% of her time on this project after it is started.

### **Roles and Responsibilities:**

Each of the three graduate students will focus on the impact of BIM on a specific area within the project lifecycle. Coleen will be leading the Owner and Facility Management value of BIM implementation, Dragana will be responsible for the Design / Engineering value of BIM implementation, and Craig will be heading the Construction value of BIM implementation. Dr. Messner will oversee the entire project, with the assistance of Deke Smith as the industry champion. We will also have undergraduate students assist with case study research.